IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
WACO DIVISION

DENSYS LTD., Plaintiff, v. 3SHAPE TRIOS A/S and 3SHAPE A/S, Defendants.	Case No. WA:19-CV-00680-ADA Jury Trial Demanded

DECLARATION OF CHANDRAJIT BAJAJ Ph.D.
IN SUPPORT OF DENSYS LTD.'S RESPONSIVE CLAIM CONSTRUCTION BRIEF

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I, Chandrajit Bajaj, Ph.D. hereby declare, as follows:

A. QUALIFICATIONS

1. My curriculum vitae ("CV"), a copy of which is provided as Exhibit C.1, provides details on my education, experience, publications, and other qualifications. It includes a list of all publications I have authored in the previous thirty-five years. It also includes a list of all other cases in which, during the previous five years, I testified as an expert at trial or by deposition.

2. I am currently employed as a Professor of Computer Science at the University of Texas at Austin ("UT Austin"). I hold the Computational Applied Mathematics endowed Chair in Visualization. I am also the Director of the Computational Visualization Center at UT Austin, which has been funded by the National Institutes of Health, the National Science Foundation, the Department of Energy, and the Department of Defense. The center's personnel include twelve researchers, scientists, post-graduate students, and staff.

3. I have a Bachelor of Technology degree in Electrical Engineering, which I obtained from the Indian Institute of Technology in Delhi (IITD) in 1980. I also have a Master of Science degree and a doctorate in Computer Science from Cornell University in 1983 and 1984, respectively.

4. Prior to my employment at the University of Texas (UT), I was an assistant professor, associate professor, and finally professor of Computer Sciences at Purdue University (Purdue) from 1984 until I resigned in 1997 and transferred to UT. During this time, I was also the Director of the Image Analysis and Visualization Center at Purdue University. I was a visiting associate professor of Computer Science at Cornell University from 1990-1991. I have also been invited for collaborative visits by several academic institutions and have presented numerous keynote presentations worldwide. I have been an editorial member of the SIAM Journal on Imaging Sciences and the ACM Transactions on Graphics, and I continue my

editorial role for ACM Computing Surveys and the International Journal of Computational Geometry and Applications.

5. I have spent the better part of my career, both at Purdue and UT, researching, designing, teaching, and using computer systems to model, simulate, and visualize natural and synthetic objects combining computational imaging and geometry processing. I am knowledgeable about and have experience in both the hardware and software, including algorithms used for capturing, analyzing, and displaying interactive imagery.

6. In the 1970s, I majored in Electrical Engineering at the Indian Institute of Technology, with a minor in Computer Sciences. There, I was intimately involved in the design and fabrication of microprocessor-controlled circuits including the development of microprocessor controller software. In the 1980s, while at Cornell University, these past experiences from my time at Indian Institute of Technology led to research in computational geometry, processing, and optimization. In the early 1990s, I created 3D interactive and collaborative multimedia software environments, which were fully navigable for multi-person computer gaming and simulation. In 1994, I co-authored a technical paper entitled “Shastra: Multimedia Collaborative Design Environment,” Vinod Anupam and Chandrajit L. Bajaj, IEEE Multimedia 1.2 (1994) 39, 39–49.

7. The increasing need for increasing computer graphics display realism without sacrificing interactivity led me also to explore image processing techniques such as texture mapping with data compression, such as described in my publications “Compression-Based 3D Texture Mapping for Real-Time Rendering,” and “3D RGB Image Compression for Interactive Applications.” During this time, I was also intimately involved with the development of a new synthetic-natural hybrid data compression MPEG (Motion Pictures Expert Group) standard.

Additionally, I applied and received a joint patent "Encoding Images of 3-D Objects with Improved Rendering Time and Transmission Process," August 2002, US Patent 6438266.

8. My work with encoding, transmission, and reconstructing 3-D objects, led me to explore image processing and geometric modeling techniques such as surface reconstruction from CT scans, point clouds, and texture mapping with data compression, such as those described in my publications: "Multi-Component Heart Reconstruction from Volumetric Imaging," and "Automatic Reconstruction of Surfaces and Scalar Fields from 3D Scans".

9. In the mid-2000s, I began to create spatially-realistic 3D graphical environments of nature's molecules and cells with a combination of different types of acquired and reconstructed imagery within which a user may explore, query, and learn. My publication, titled "From Voxel Maps to Models," which appeared in an Oxford University Press book called *Imaging Life: Biological Systems From Atoms To Tissues*, Gary C. Howard, William E. Brown & Manfred Auer eds., Oxford University Press, 2015, is an example of my research in computational imaging.

10. Throughout my career, I have participated in the design and use of several computer systems spanning handhelds, laptops, and graphics workstations to PC/Linux clusters as well as very large memory supercomputers for capturing, modeling, and displaying virtual and scientific phenomena. My experience with computer modeling and displaying computer graphics imagery encompasses many fields, such as interactive games, molecular, biomedical and industrial diagnostics, oil and gas exploration, geology, cosmology, and military industries.

11. During my time at UT Austin, I also designed and implemented scalable solutions for inverse problems in microscopy, spectroscopy, biomedical imaging, constructing spatially realistic and hierarchical 3D models, development of search/scoring engines for predicting

energetically favorable multi-molecular and cellular complexes, and statistical analysis and interrogative visualization of neuronal form-function. Additionally, I have courtesy appointments with, and supervise masters and doctoral students from several UT departments, including biomedical and electrical engineering, neurobiology, and mathematics.

12. I currently serve on the editorial boards for the International Journal of Computational Geometry and Applications and the ACM Computing Surveys. Much of my work involves issues relating to interactive image processing, 3D modeling, bio-informatics, computer graphics, and computational visualization. Examples of my publications, including peer-reviewed publications, are listed in my curriculum vitae.

13. As outlined in my curriculum vitae, I have authored approximately 165 peer-reviewed journal articles, 34 peer-reviewed book chapters, and 151 peer-reviewed conference publications.

14. I have written and edited four books, on topics ranging from image processing, geometric modeling, and visualization techniques, to algebraic geometry and its applications. I have given 198 invited speaker keynote presentations. I am a Fellow of the American Association for the Advancement of Science, a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), a Fellow of the Society of Industrial and Applied Mathematics (SIAM), and a Fellow of the Association of Computing Machinery (also known as ACM), which is the world's largest education and scientific computing society. ACM Fellow is ACM's most prestigious member grade and recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community.

15. I have been asked by counsel representing the plaintiff to provide my opinions in this declaration concerning the opinions expressed by Dr. Parris Egbert in his declaration in support of the Defendants' claim construction positions.

B. DISPUTED TERMS OF THE '707 PATENT

1. "an intra-oral fixed global registration position inside the oral cavity"

16. I agree with Dr. Egbert's opinion expressed in paragraph 21 of his declaration that "the specification provides a clear and consistent teaching that the intra-oral fixed global registration position is a fixed position inside the oral cavity that is used as a reference point for relating multiple sets of 3D data to a global coordinate system." *S*ee Egbert Decl. at ⁋ 21.

17. But I disagree with Dr. Egbert's opinion where he states in paragraph 23 of his declaration that "a person of ordinary skill in the art, after reading the entirety of the specification and in the context of the independent claims, would have understood that the fixed position is defined *prior to* measuring and imaging." *S*ee Egbert Decl.[1] I have read the claims and the specification, and believe that there are fundamental flaws in Dr. Egbert's conclusion.

18. Dr. Egbert's opinion is that the fixed global registration position must be defined before *any* measuring and imaging. He states in paragraph 24 that "[t]he basis for [his] conclusion is the nature of the measuring and imaging described in this patent – it involves determining the position of the measuring and imaging device measured from the intra-oral fixed global registration position." *S*ee Egbert Decl. at ⁋ 24.

19. At the outset, I am uncertain as to what Dr. Egbert means when he refers to the "nature" of the measuring and imaging device. In my opinion, the "nature" of the measuring and imaging device does not include determining its location relative to the intra-oral fixed global

[1] All emphasis included herein is added unless stated otherwise.

registration position. Certainly, the claims and the specification provide for determining the location of the measuring and imaging device relative to the fixed global position; that is an aspect of the claimed invention. *See e.g.*, ’707 patent at 17:11-19:28. But in my opinion, the “nature” and fundamental purpose of the measuring and imaging device is to measure and image objects and features in the oral cavity of a dental patient. Indeed, it appears that Dr. Egbert is conflating different aspects or steps of the claimed invention to support his opinion. As the patent specification states, the measuring and imaging device is provided “for measuring and imaging intra-oral objects and features, and for locally programming and processing measurement and imaging data and information,” (’707 patent, 15:6-9), while the mobile registration device is used for measuring and recording the global positions and orientations of the measuring and imaging device relative to the fixed global registration position (’707 patent, 17:11-14).

20. In paragraph 25 of his declaration, Dr. Egbert says, “[s]ince the measuring and imaging process includes a determination of the position of the measuring and imaging device 36 from the intra-oral fixed global registration position, in [his] opinion logic necessitates the conclusion that the intra-oral fixed global registration position must have been established prior to measuring and imaging.” *See* Egbert Decl. at ⁋ 25. Dr. Egbert goes on to state that a person skilled in the art “would have readily appreciated that it is not possible to determine the position of one object relative to a second position if the second position has not been defined.” *Id.* But that statement does nothing to support Dr. Egbert’s opinion. I agree that it would not be possible to determine the position of the measuring and imaging device without also defining the fixed global registration position. That it is possible to determine the position of the measuring and imaging device (position one in Dr. Egbert’s statement) relative to the fixed global registration (position two in Dr. Egbert’s statement) does not mean that the fixed global registration position

must be established first. If A is relative to B, then both A and B must be known. But it does not follow that B must be known before A or vice versa. More importantly, however, Dr. Egbert's statement has nothing to do with whether the fixed global registration position must be established *before measuring and imaging objects and features in the oral cavity*. Again, Dr. Egbert is conflating different aspects of the claimed invention. That the mobile registration device measures and records the position of the measuring device relative to the fixed global registration position does *not* mean that the fixed global position *must* be defined before any measuring and imaging of intra-oral objects and features occurs, as Dr. Egbert concludes.

21. I disagree with Dr. Egbert where he states in paragraph 25 of his declaration that "[s]ince the measuring and imaging process includes a determination of the position of the measuring and imaging device 36 from the intra-oral fixed global registration position, in [his] opinion logic necessitates the conclusion that the intra-oral fixed global registration position must have been established prior to measuring and imaging." The fundamental rationale underlying Dr. Egbert's opinion is flawed; he conflates different aspects of the claimed invention to state that the fixed global registration position must be defined prior measuring and imaging. The fallacy of Dr. Egbert's opinion is that acquiring measurements and images of objects and features in the oral cavity with the measuring and imaging device is distinct from the task of determining the position of the measuring and imaging device relative to the fixed global registration position. The specification explains that there is acquiring at least one 3-D measurement and image of the intra-oral objects and features located in the selected field of view of the measuring and imaging device, *and* recording the global position of the measuring and imaging device relative to the fixed global registration position. Where those two aspects of the claimed invention come together is when at least one globally recorded 3-D measurement and

image of the intra-oral objects and features in the oral cavity is formed. *See* ’707 patent at 20:31-39.

22. In my opinion, there is no logical basis to support a conclusion that the intra-oral fixed global registration position must be established before using the measuring and imaging device to measure and image intra-oral object and features simply because the position of the measuring and imaging device is later recorded relative to intra-oral fixed global registration position, which is all that the independent claims require. In fact, the specification explains this. Sub-step 5(a) is using the measuring and imaging device to acquire at least one 3-D measurement and image of intra-oral objects and features in a selected field of view of the measuring and imaging device located at a particular global position in the global coordinate space of the oral cavity. This step also includes storing the 3-D measurement and image by a central programming and processing unit. *Id.* at 20:40-58. Sub-step 5(b) is recording the global position of the measuring and imaging device relative to the fixed global registration position in the global coordinate space of the oral cavity. This is done with the mobile registration device, preferably attached to the measuring and imaging device and associated with the global position of the measuring and imaging device. This step also includes storing the global position of the measuring and imaging device relative to the fixed global registration device by a central programming and processing unit. *Id.* at 20:59-21:9.

23. The specification then goes on to state that steps 5(a) and 5(b) “are performed synchronously or asynchronously.” *Id.* at 21:10-11. “In particular,” sub-step 5(b), which is recording and storing the position of the measuring and imaging device relative to the fixed global registration position in the global coordinate space “is performed *at a real time* selected from the group consisting of *before, simultaneous to, and after, sub-step(a)* of acquiring and

storing at least one three-dimensional measurement and image of intra-oral objects and features . . . located in . . . field of view . . . of [the] measuring and imaging device." *Id*. at 21:11-20. The patent specification's explanation about the ways in which the steps can be performed contradicts Dr. Egbert's opinion that the fixed global registration position *must* be defined before measuring and imaging. The specification states that "[t]his feature," *i.e.*, that steps 5(a) and 5(b) can be performed synchronously or asynchronously, "provides operational flexibility for implementing the method and system of the present invention." *Id*. at 21:20-22. The specification's disclosures necessarily mean that the measuring and imaging device can measure and image intra-oral objects and features, and store those measurements and images before establishing the fixed global registration position, and measuring and recording the position of the measuring and imaging device relative to the fixed global registration position.

24. Thus, contrary to Dr. Egbert's opinion there is no logical reason why the establishment of the intra-oral fixed global registration position cannot occur after the claimed system acquires one or more measurements and images and before those measurements and images are recorded.

25. Moreover, and again contrary to Dr. Egbert's assessment and opinion, as the claims and specification explain, the intra-oral fixed global registration position involves or culminates from "*establishing* an intra-oral fixed global registration position inside the oral cavity of the dental patient, said intra-oral fixed global registration position is *definable* in terms of global coordinate space of the oral cavity, said global coordinate space is associated with a fixed global reference coordinate system, said global coordinate space includes a plurality of intra-oral local coordinate spaces in the oral cavity;" *See* '707 patent, at claim 1; 12:30-15:51. The "establishing" of the intra-oral fixed global registration position **28** inside the oral cavity **26**

is coupled to determining the global coordinate space with sufficient coverage to register the positions of all objects and features and instruments including the measuring and imaging device **36** throughout the oral cavity. *See* ’707 Patent at Fig. 1, reproduced below.

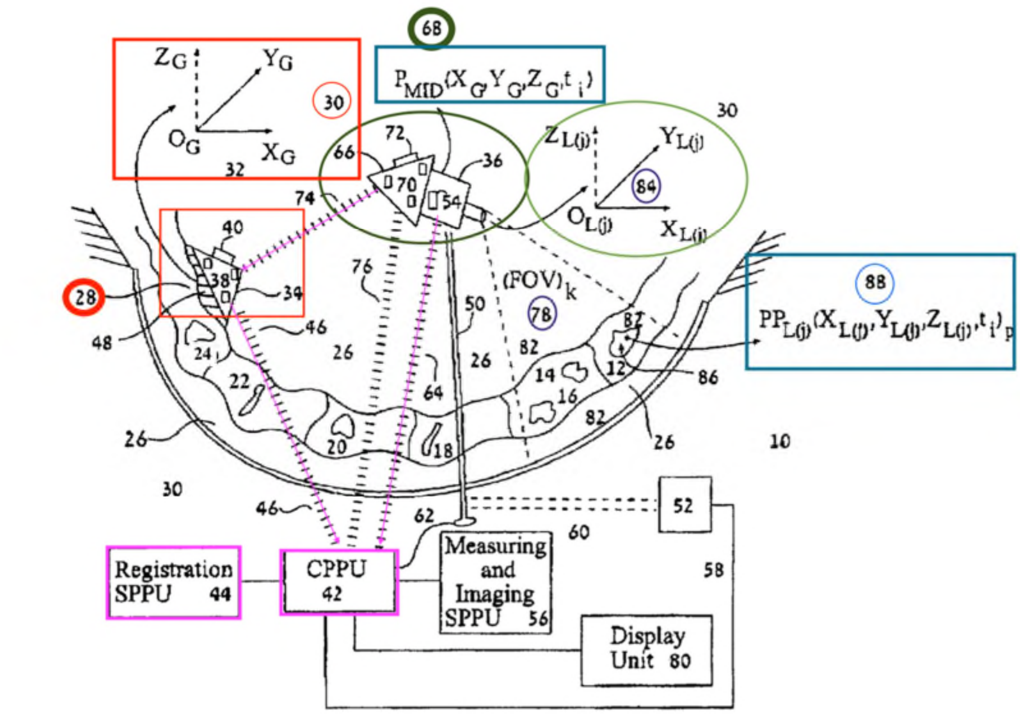


FIG.1

26. The specification provides that the “intra-oral fixed global registration position **28,** global coordinate space **30,** and associated fixed global reference coordinate system **32** are established particularly for defining positions of fixed and/or movable objects, features, devices, instruments, and components, throughout oral cavity **26**” *See* ’707 patent at 12:46-51. The specification then further provides that in sub-step (a), of Step 1, an intra-oral fixed global registration device **34**, is used for measuring and determining distances from intra-oral fixed global registration position **28** to a measuring and imaging device, such as **36,** further described below. *See* ’707 patent at 12:58-65. In sub-step (b), there is selecting and attaching a substrate for holding intra-oral fixed global registration device **34.** *Id.* at 14:1-4. Alternatively, during non-

use of a substrate one continues to sub-step (c***),*** whereby intra-oral fixed global registration device **34** is positioned and fixed directly onto an intra-oral object and/or feature inside oral cavity **26** of the dental patient. *Id.* at 14:2-8. The specification then provides that for Sub-step (c), which includes *positioning and temporarily fixing* intra-oral fixed global registration device **34** to any intra-oral object or feature inside oral cavity **26** in such a way as to remain fixed and rigid with respect to that intra-oral object and/or feature **12-24** during movement or activity of any other object, feature, device, instrument, component, or, the entirety, of oral cavity 26 of the dental patient during the measuring and imaging procedure." *Id.* at 14:23-65. There is thus no temporal order specified in establishing this intra-oral fixed registration position, but when it is finally fixed, it needs to meet all the limitations and requirements of measurement coverage of the **entirety oral cavity 26**. This is clearly achieved with all of the disclosed means, devices, and communication, including preliminary scouting position measurements from the measurement and imaging device **36** using its multiple registration **66** and communication components **54**, to ensure its reachable anywhere in the oral cavity 26. *See* annotated Fig. 1 above showing these communications pathways between the various devices and registration modules in the oral cavity **26**. The specification then provides that "[c]ompletion of this step enables proper establishment of the intra-oral fixed global registration position." *See* '707 patent at 14:66-67.

27. Additionally and again contrary to Dr. Egbert's opinion, the optimal establishing of the intra-oral fixed global registration position inside the oral cavity, as substantiated by the '707 specification, could easily be part of or subsequent to the initiation of the measuring and imaging process. The patent teaches that there is an intra-oral fixed global registration device 34 [that] includes a mechanism for sensing or receiving registration signals and responding to registration signals" from the measurement and imaging device 36. The device 34 includes a

local registration signal programmer and processor (RSPPU) 40 for locally programming and processing registration signals. "Intra-oral fixed global registration device 34 in general, and device components 38, optional local registration signal processor and programmer 40, and registration signals in particular, are designed, configured, and operate under a category of mechanisms used for measuring distances and recording positions of objects and features selected . . . ." *See e.g.* '707 Patent at 13:26-36. The inclusion of these components would suggest to a person of ordinary skill in the art that the establishment on the intraoral fixed global registration position could easily be part of, or subsequent to, the initiation of the measuring and imaging process.

28. It is for all these reasons that I disagree with the opinion Dr. Egbert's expressed in paragraph 25 of his declaration.

2. "a fixed global reference coordinate system"

29. I disagree with Dr. Egbert where he says in paragraph 35 of his declaration that "a person of ordinary skill in the art would have interpreted [Figure 1 of the '707 patent], and the accompanying description in the specification, as teaching that the fixed global coordinate system is *defined by* the intra-oral fixed global reference position 28." As an initial matter, a person of ordinary skill in the art would recognize that the definition of an orthogonal global coordinate system 32, such as the one represented in Figure 1, is not simply defined by a single position as he argues, but requires at minimum, six parameters, three to fix the global coordinate system origin O_G and three additional parameters to establish the directions of the three global coordinate axes, namely X_G-axis , Y_G-axis, and Z_G-axis to define a coordinate space with sufficient coverage to include multiple possible locations of intra-oral local coordinate spaces.

30. Moreover, the claims provide that the "global coordinate space is associated with a fixed global reference coordinate system, said global coordinate space includes a plurality of

intra-oral local coordinate spaces in the oral cavity**,"** (*See e.g.* '707 Patent at claim 1), and the specification provides that "[t]he intra-oral fixed global registration position 28, global coordinate space 30, and associated fixed global reference coordinate system 32 are established particularly for defining positions of fixed and/or movable objects, features, devices, instruments, and components, *throughout oral cavity* 26."*See Id.* at 12:45-21. Additionally, Figure 1 establishes that the fixed global reference coordinate system describes a coordinate space that merely includes the intra-oral fixed global reference position; there is no requirement that the fixed global reference position be mapped to the origin point of the fixed global reference coordinate system. *See e.g. Id.* at 12:41-45. ("In principle any … coordinate system, can be used for defining the fixed global reference coordinate system, *associated with global coordinate space **30** of oral cavity* **26**.") All that the patent requires is that the fixed global reference coordinate system meets the entirety of the coverage of the oral cavity.

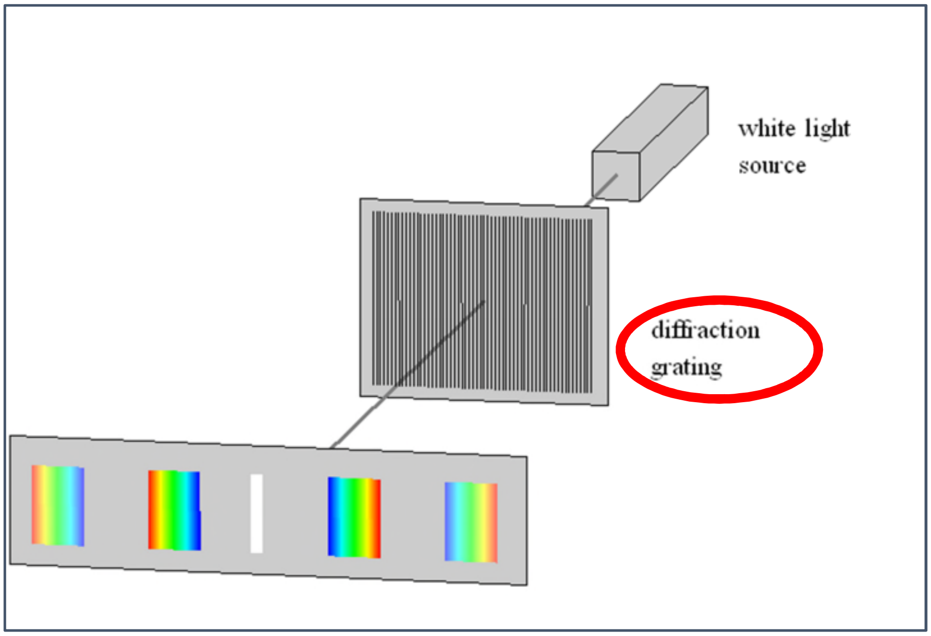
31. I further disagree with Dr. Egbert's assertion that his conclusion is required based on the portion of the specification he cites. *See* Egbert Decl. at ¶¶ 35-36, *citing* '707 Patent, 12:18-45. In fact, that passage of the specification merely confirms that the intra-oral fixed global registration position is established within the oral cavity (*i.e.* the global coordinate space of the oral cavity), and that the oral cavity is associated with the coordinate system, but does *not* require that the coordinate system be "defined" by the intra-oral fixed global reference coordinate position as Dr. Egbert concludes.

3. "a measuring and imaging device (for measuring and imaging the intra-oral objects and features)"

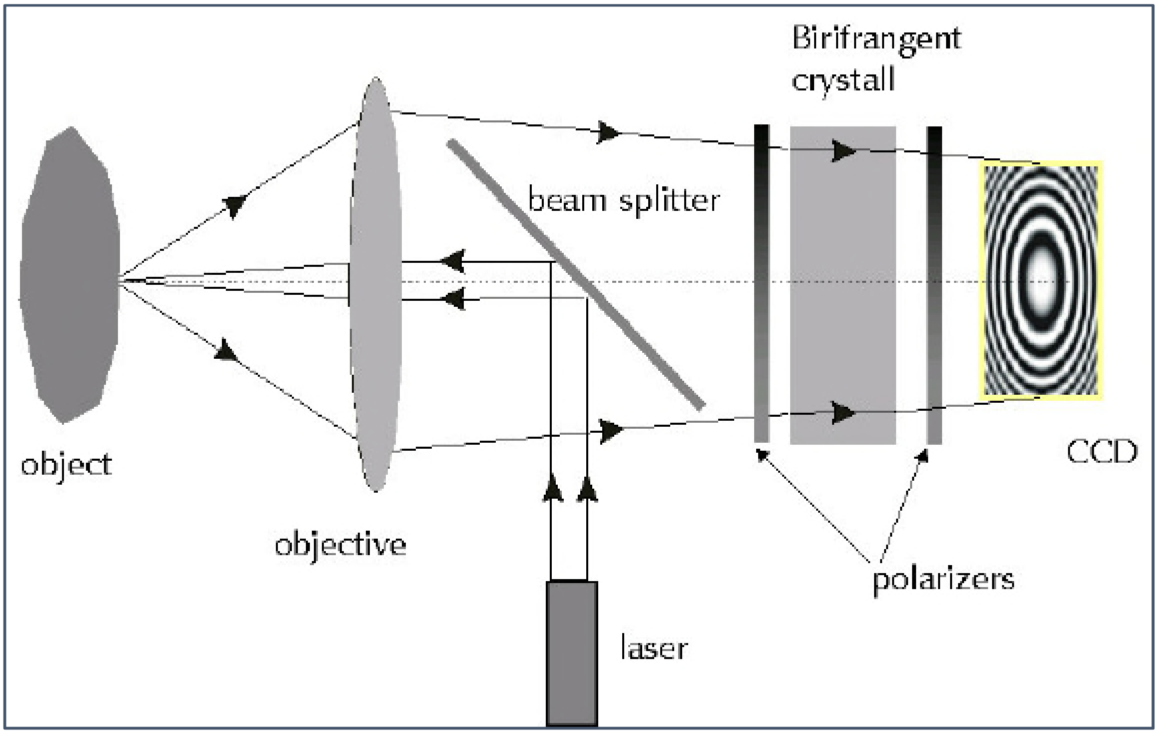
32. I disagree with the opinion Dr. Egbert expressed in paragraph 38 of his declaration that "the term 'measuring and imaging device' is not a known term in the art that would have conveyed any particular meaning connoting any particular structure(s) to one of

ordinary skill in the art." *See* Egbert Decl. at ⁋ 38. It is my opinion that within the field of three-dimensional dental imaging, the term "measuring and imaging device" would have been well understood by a person of ordinary skill in the art to connote structure at the time of the '707 invention.

33. In my opinion, the specification's disclosure that "the measuring and imaging device 36 operates in the particular category of electro-optical measuring and imaging techniques" (*see* '707 Patent, 16:22-44), would have indicated to a person of ordinary skill in the art that the measuring and imaging device is structural. To cite some of the easier to understand examples of why this is so, the specification's disclosure that the "measuring and imaging device" can employ "laser scanning," "laser speckle pattern sectioning," or "laser tracking" measuring and imaging techniques necessarily discloses to a person of ordinary skill in the art that the "measuring and imaging device" is a structure that at minimum can include structural components such as a *physical laser emitting device* and/or *photo detectors*. The same can be said of all of the electro-optical measuring and imaging techniques listed in the specification and the related structural components that a person of ordinary skill in the art would have understood were being disclosed, (*see* '707 Patent, 16:22-44). Additional examples also include the disclosure of a "diffraction grating" technique, (*See e.g. Id.* at 4:64; 5:12-13; 16:34-44), which intuitively would have implied to a person of ordinary skill in the art that the "measuring and imaging device" would have a physical and structural component known in the art as a "diffraction grating" as demonstrated by the image below:



The same can also be said for the disclosed example relating to the "conoscopic holography" technique, (*See e.g. Id.* at 16:34-44) which would have implied to a person of ordinary skill in the art that the "measuring and imaging device" would have physical and structural components including a laser light source, a beam splitter, one or more lenses, polarizers, and a birefringent crystal, etc. as is demonstrated by the image below:



34. As a further example of what a person of ordinary skill in the art would have appreciated from reading the ’707 patent, the electro-optical measuring and imaging techniques that are discussed therein are reviewed by Chen, F., in “Overview of three-dimensional shape measurement using optical methods,” Opt. Eng. 39(1) 15 Jan., 10---22, 2000, (*See* Exhibit “C.2”), which is cited as support for the disclosures in the specification, and demonstrate that a person of ordinary skill in the art would have understood that those electro-optical techniques would have involved structural elements as shown by the table reproduced below:

Table 1 Some Full Field Shape Measurement Commercial Systems Based on Leading Edge Technologies

System	Principle	Accuracy Dependent on Volume
Atos System Caputure 3D, Costa Mesa, CA 92626, 1-714-546-7278	Structured light+photogrammetry; 360-deg view/patching	About 50 μm (2σ) on a relatively large volume
Comet/OptoTrak System 4000 Grand River Avenue, Suite 101, Novi, MI 48375, mikeb@steinbichler.com	Structured light+optical tracking; 360-deg view/patching	About 50 μm (2σ) on a relatively large volume
Optigo/CogniTens System U.S. 815-637-1926	Random dot pattern+photogrammetry +trilinear tensor; 360-deg view/patching	About 20 to 100 μm (2σ) on a relatively large volume
4DI System IA, 149 Sidney Street, Cambridge, MA 02139, 617-354-3830	Structured light+real time computing; one view/no patching	About 10^{-3} on a medium volume
HoloMapper System ERIM International, Inc., 1975 Green Road, Ann Arbor, MI 48105, 313-994-0287	Laser radar/multiple wavelength; one view/no patching	Uncertainty 0.5 μm on a medium volume

Table 1 lists field shape measurement and imaging devices utilized by commercialized systems that were available for purchase at the that time of the invention. In particular, and as referenced by the ’707 patent, the category of electro-optical mechanisms used in measuring and imaging devices includes, for example, time/light - in-flight, laser scanning, Moire, laser speckle pattern sectioning, interferometry, photogrammetry, laser tracking, and structured light or active triangulation.

35. Similar to the survey by Chen, *et al.*, and as described in the specification of the ‘707 patent, several of these electro-optical techniques, such as laser scanning, Moire, laser speckle pattern sectioning, interferometry, photogrammetry, laser tracking, and structured light or active triangulation had been specifically applied to and used for measuring, imaging, and mapping intra-oral objects and features at the time of the invention. *See* ’707 patent at 4:40-44 (disclosing structural measuring and imaging device components including a “laser diode” for projecting a triangulating beam which scans the surface of intra-oral objects and features); *Id.* at 4:52-64 (disclosing structural measuring and imaging device components including a light projector, diffraction grating, and video camera); *Id.* at 4:65-5:5 (disclosing structural measuring

and imaging device components including an optical probe, "a mobile two-dimensional LCD matrix plate pattern projection unit, optic fibers projecting patterned light beams into the oral cavity, and a CCD matrix image sensor, operating in accordance with moire, phase-shift, triangulation, and photogrammetry techniques."); *Id.* at 5:22-25 (disclosing structural measuring and imaging device components including "light pattern projector and an imaging device such as a CCD matrix image sensor, operating in accordance with moire, phase-shift, and triangulation techniques); *Id.* at 5:34-46 (disclosing structural measuring and imaging device components including a "CCD matrix camera for photographing moire fringes," and an "imaging system including a projector device, a grating, mirrors, and, stepping motors and springs for fine positional control of the grating"); *Id.* at 5:47-65 (disclosing structural measuring and imaging device components including "intra-oral optical radiation projection scanning device including light interference and deflection elements.")

36. I disagree with the opinion Dr. Egbert expressed in paragraphs 39-40 of his declaration that the specification does not disclose the structure of a measuring and imaging device, as I explain above. But in that regard, the three arguments that Dr. Egbert relies on are simply wrong and irrelevant. The portion of the specification he discusses ('707 patent, 16:22-32), actually discloses numerous structural elements of the "measurement and imaging device." In my opinion, the '707 patent specification's disclosure of electromechanical mechanisms, electro-optical mechanisms, electromagnetic mechanisms, radar mechanisms, magnetic mechanisms, magneto-mechanical mechanisms, magnetic resonance mechanisms, acoustic mechanisms, ultrasound mechanisms, sonar mechanisms, photo-acoustic mechanisms, and telemetry mechanisms would convey a structural understanding to a person of ordinary skill in the art at the time of the invention. Moreover, I base my opinion in part on the fact that the

specification provides specific examples of hardware, which belong to the above-listed categories of mechanisms. (*See e.g.* ’707 Patent, 2:50-58, which provides that the “[i]mplementation of an automatic measuring and imaging technique **includes measurement and image processing hardware and software**, for automatically performing mathematical operations involved in registering local with global coordinate spaces during and/or after measurement and imaging, and for manipulating and editing measurements and images acquired in local and/or global coordinate spaces. Three-dimensional shape measurement, imaging, and mapping of objects and features, such as intra-oral objects and features, requires the positioning of **at least one measuring and imaging device such as an electro-optical measuring and imaging probe, an electromagnetic measuring and imaging probe, an ultrasound measuring and imaging probe, or a magnetic resonance measuring and imaging probe**, at different locations within source or global coordinate space, such as the oral cavity or mouth of a dental patient.”). *See also* ’707 patent at 4:40-44; 4:52-64; 4:65-5:5; 5:22-25; 5:34-46; 5:47-65.

37. I further disagree with Dr. Egbert’s opinion at paragraph 40 that “combinations” of the above-listed mechanisms are incapable of connoting structure to a person of ordinary skill in the art, as the process of registering multiple measuring and imaging modalities in a single imaging system was a well-known problem in the field of computer imaging at the time of the invention. I also note that there are additional portions of the specification that establish the structural elements of the claimed measurement and imaging device that Dr. Egbert appears to have ignored entirely in his analysis. *See e.g.* ’707 Patent, 1:62–2:20; 16:22-63, claims 6, 16-26, 32, 42, 52-61.

38. To elaborate from the patent specification, the measuring and imaging device 36 **(**In FIG. 1 of the patent) is for acquiring three-dimensional measurements and images of the

intra-oral objects and features, for example, intra-oral objects and programming and processing unit, MISPPU **56,** via control/data links **62,** for receiving centralized measuring and imaging device position and orientation control data and information from CPPU **42,** and for sending local position and orientation data and information to CPPU **42.** measuring and imaging device **36** includes, among the variety of standard components and mechanisms for enabling measuring, imaging, and mapping, intra-oral objects and features, (i) a position and orientation guide **50,** (ii) an optional position and orientation guide automatic controller **52,** and (iii) a local measuring and imaging programming and processing unit **54.** The position and orientation guide **50** is for three-dimensional maneuvering or guiding, positioning, and orienting measuring and imaging device **36** throughout global coordinate space **30,** typically, but not limited to, inside oral cavity **26** of the dental patient. In a preferred embodiment, position and orientation guide **50** is designed, configured, and operates for enabling automatic, such as robotic, three-dimensional maneuvering or guiding, positioning, and orienting of measuring and imaging device **36** by an operator, such as a dental practitioner. In this embodiment, position and orientation guide **50** features appropriate electromechanical means (not shown), including electromechanical control/ data links **60,** for enabling automatic control and communication of position and orientation guide **50** by position and orientation guide automatic controller **52.** Moreover, in this preferred embodiment, the position and orientation guide automatic controller **52** is in electronic communication with a central programming and processing unit, for example, CPPU **42,** including a measuring and imaging signal programming and processing unit, MISPPU **56,** via control/data links **62,** for receiving centralized measuring and imaging device position and orientation control data and information from CPPU **42,** and for sending local position and orientation data and information to CPPU **42.** The local measuring and imaging programming

and processing unit **54** is for locally programming the measuring and imaging of intra-oral objects and features **12-24** by locally controlling activation and operation of measuring and imaging device **36,** and is for locally processing measurement and features **12-24,** located in oral cavity **26** of the dental patient. Furthermore, the measuring and imaging device **36** is designed and configured for operating either inside or outside of oral cavity **26,** for acquiring measurements and images of intra-oral objects and features. For example, according to actual image signals, data, and information relating to intra-oral objects and features **12-24 (see Fig 1 of the patent).**

39. The measuring and imaging device **36,** as further explained in the specification and claims**,** in combination with the above indicated components **50, 52, 54, 58, 60,** and **62,** are designed, configured, and operate according to a category of mechanisms used for automatic three-dimensional shape measurement, imaging, and mapping of objects and features selected from the group consisting of electrical, electronic, electromechanical, electro-optical, electromagnetic, radar, magnetic, magneto-mechanical, magnetic resonance, acoustic, ultrasound, sonar, photo-acoustic, telemetry, hybrids, and combinations of these. For example, an embodiment of the measuring and imaging device **36** operates in the particular category of electro-optical measuring and imaging techniques, according to a technique selected from the group consisting of time/light in flight, laser scanning, Moire, laser speckle pattern sectioning, interferometry, photogrammetry, laser tracking, and, structured light or active triangulation. Moreover, measuring and imaging device **36** can also operate according to a specialized interferometric technique such as shearography, diffraction grating, digital wavefront reconstruction and wavelength scanning, or conoscopic holography. In a preferred embodiment of system **10** featuring a wireless communications mode, measuring and imaging device **36** is in

communication with a central programming and processing unit, for example, CPPU **42,** including a measuring and imaging signal programming and processing unit, MISPPU **56,** via a wireless communication link **64,** for receiving centralized measuring and imaging programming and processing data and information from CPPU **42,** and for sending local measuring and imaging programming and processing data and information to CPPU **42.** Wireless communication link **64** is preferably, but not limited to, a form of an electromagnetic signal such as a radio wave signal, a microwave signal, or a sound wave signal. In an alternative embodiment of system **10** featuring a wired communications mode, measuring and imaging device **36** is in electronic communication with a central programming and processing unit, for example, CPPU **42,** including a measuring and imaging signal programming and processing unit, MISPPU **56,** via wired control/data links, for example, bundled along or through position and orientation guide **50** and control/data links **62,** for receiving centralized measuring and imaging programming and processing data and information from CPPU **42,** and for sending local measuring and imaging programming and processing data and information to CPPU **42.** The wired communication link is preferably, but not limited to, a form of an electrical or electronic signal. (See 707 patent, 2:45-58, 15:5-17:10, claims 17-20, 53-56)

4. "recording said global position of said measuring and imaging device relative to said intra-oral fixed global registration position"

40. I disagree with the opinion Dr. Egbert expressed in paragraph 42 of his declaration that "the specification of the '707 Patent makes quite clear, however, that the intended meaning in claim 1 is 'recording the global position of the measuring and imaging device (*sic*, *recte* "measured") from the intra-oral fixed global registration position.'" Although Dr. Egbert provides citations to the specification, those citations do not support his conclusion. It is my opinion that a person of ordinary skill in the art would understand the words "relative to"

to be different from "measured from" in Defendants' proposed construction. This is easily discernable from the specification's teaching that "[i]n order to register point clouds or, measuring and imaging data associated with objects and features located in such local coordinate spaces, in terms of the global coordinate space, each measuring and imaging device coordinate system location and orientation must be accurately and precisely **known or measured**. Any error in **measuring and/or calculating** the measuring and imaging device location and orientation causes propagation error in the registration procedure, thereby decreasing accuracy and precision of final output data and information, such as measurements and images, and/or maps, of the particular objects and features of interest." *See* '707 patent, 3:62-4:6. The fact that the location of the measuring and imaging device can either be "**known** or measured" through the process of "measuring and/**or calculating**" demonstrates that when the patent speaks of recording the position of the measuring and imaging device **relative to** the intra-oral fixed global registration position, it is not exclusively speaking of "measured" positions, but rather includes positions that are the product of some calculation. Thus, Defendants' and Dr. Egbert's proposed construction is unduly narrow.

41. My conclusion is further supported by additional passages in the specification, which consistently speak of recording of the global position of the measuring and imaging device "relative to" the intra-oral fixed global registration position. *See e.g.* '707 patent, 20:30-21:22. For example, there are two sub-steps that constitute step 5 of the method detailed in the '707 patent specification for real time intra-oral acquisition and registering of three-dimensional measurements and images of the intra-oral objects and features in the oral cavity of the dental patient. These are the (i) guided acquisition of three-dimensional measurement and images of the intra-oral objects and features located in the selected field of view (FOV) of the measuring and

imaging device, and the (ii) **recording of the global position of the measuring and imaging device relative to the intra-oral fixed global registration position**, for forming at least one globally recorded three-dimensional measurement and image of the intra-oral objects and features located in the oral cavity of the dental patient. In the first sub-step (i) and referring to FIG. 1 of the '707 patent**,** there is acquiring at least one three-dimensional measurement and image of intra-oral objects and features **12, 14,** and **16** located in an exemplary k^{th} field of view, $(FOV)_k$ **78,** of measuring and imaging device **36,** by activating and operating measuring and imaging device **36,** located at a particular global position, for example, j^{th} global position P*MID* $(X_G, Y_G, Z_G, t_i)_j$ **68,** in global coordinate space **30** of oral cavity **26** of the dental patient. This involves central programming and processing unit **42** communicating with local measuring and imaging programming and processing unit **54,** preferably, but not limited to, via wireless communication link **64.** Following acquiring the at least one three- dimensional measurement and image of intra-oral objects and features **12, 14,** and **16,** this step further includes storing the at least one three-dimensional measurement and image by central processing and programming unit **42,** for example, by operation of measuring and imaging signal processing and programming unit, MISPPU **56.** In the second sub-step (b), of Step 5, there is the **recording of the j^{th} global position P*MID* $(X_G, Y_G, Z_G, t_i)_j$ 68 of measuring and imaging device 36 relative to the intra-oral fixed global registration position 28** in global coordinate space **30** of oral cavity **26** of the dental patient. This involves use of the mobile registration device **66,** preferably firmly and rigidly attached to the measuring and imaging device **36** and associated with j^{th} global position P*MID* $(X_G, Y_G, Z_G, t_i)_j$ **68** of measuring and imaging device **36,** communicating with intra-oral fixed global registration device **34,** preferably, but not limited to, via wireless communication link **74.** Following **recording the j^{th} global position P*MID* $(X_G, Y_G, Z_G, t_i)_j$ 68 of measuring**

and imaging device 36 relative to intra-oral fixed global registration position 28 in global coordinate space **30,** this step further includes storing the globally recorded position by central processing and programming unit **42,** for example, by operation of registration signal processing and programming unit, RSPPU **44.** As stated in the specification **"**Both sub-steps (a) and (b) of Step 5, can be performed synchronously or asynchronously. In particular, sub-step (b) of **recording and storing j^{th} global position P*MID* (X_G, Y_G, Z_G, $t_i)_j$ 68 of measuring and imaging device 36 relative to the intra-oral fixed global registration position 28** in global coordinate space **30** is performed at a real time selected from the group consisting of before, simultaneous to, and after, sub-step (a) of acquiring and storing at least one three- dimensional measurement and image of intra-oral objects and features **12, 14,** and **16** located in k^{th} field of view $(FOV)_k$ **78** of measuring and imaging device **36.** This feature provides operational flexibility for implementing the method and system of the present invention." *See* 707 patent '707 patent, 20:30-21:22.

5. "measuring and recording global positions and orientations of said measuring and imaging device relative to same said intra-oral fixed global registration position"

42. For all the reasons mentioned earlier and stated above, I disagree with the opinion Dr. Egbert expressed in paragraph 47 of his declaration that "a person of ordinary skill in the art would have understood that "relative to" should be understood as "measured from" as the words carry different meanings and "relative to" is well-supported by the specification.

6. "(f) registering local coordinate space pixel positions in each of said plurality of globally recorded three-dimensional measurements and images with corresponding global coordinate space pixel position"

43. I disagree with the opinion Dr. Egbert expressed in paragraph 52 of his declaration that "a person of ordinary skill in the art of computer modelling would have understood that the registration technique disclosed in this patent involves registering local

coordinate space pixel positions in each of the plurality of globally recorded three-dimensional measurements and images after the plurality of globally recorded three-dimensional measurements and images are acquired (by repeated steps 4 and 5, as discussed in the specification)." Dr. Egbert's interpretation of the disputed claim language, wherein registration is held in abeyance until all measurements and images have been acquired does not comport with "enabling the **real time registering** of all local coordinate space pixel positions of the acquired and globally recorded three-dimensional measurements and images" that is disclosed in the specification. (*See e.g.* '707 Patent, 11:37-39*).*

44. I also disagree with the opinion Dr. Egbert expressed in paragraph 51 of his declaration that "a person of ordinary skill in the art would have understood that since the specification discusses explicitly that sub-step 5(b) is performed "before, simultaneous to, and after" sub-step 5(a) ('707 Patent, 21:11-16.) that the inventor intended for certain steps to be performed in any order (*e.g.*, sub-steps 5(a) and 5(b)), whereas other steps were intended to be performed in the order described (*e.g.*, Step 7 after Step 6) as the inventor used clear language when a particular order was not intended." Such a counterfactual argument is of twisted portent as it is based on the obvious flexibility in the order, of whether you first record the position from where you acquire three-dimensional measurements and images (step 5 (b)) and then perform the actual acquisition of three-dimensional measurements and images (step 5 (b)), or do it the other way around.

45. Furthermore, such an opinion from Dr. Egbert as above, holds no basis for the then subsequent conclusory opinion Dr Egbert expressed in paragraph 52 of his declaration. Namely, his conclusion is that because of the order flexibility indicated above, it must follow "that a person of ordinary skill in the art of computer modelling would have understood that the

registration technique disclosed in this patent involves registering local coordinate space pixel positions in each of the plurality of globally recorded three-dimensional measurements and images **after** the plurality of globally recorded three-dimensional measurements and images are acquired (by repeated Steps 4 and 5, as discussed in the specification)."

46. In addition, the claims (and the specification) of the '707 patent clearly states that element (*f*) applies to "**each of** said plurality of globally recorded three dimensional measurements" rather than to the entirety of the measurements in their totality. There are three sub-steps that constitute Step 7 of the method detailed in the '707 patent specifications for real time intra-oral acquisition and registering of three-dimensional measurements and images of the intra-oral objects and features in the oral cavity of the dental patient. Sub-step (a) requires defining an intra-oral *local* coordinate space, associated with an intra-oral *local* reference coordinate system, for **each** *global* position of the measuring and imaging device. " In **FIG. 1,** for example, there is defining intra-oral local coordinate space **82,** associated with intra-oral local reference coordinate system **84,** featuring local orthogonal reference coor-dinate system axes, $X_{L(j)}$-axis, $Y_{L(j)}$-axis, $Z_{L(j)}$-axis, and local reference coordinate system origin, $O_{L(j)}'$ for each $\boldsymbol{j^{th}}$ **global position P*MID* ($\mathbf{X_G}$, $\mathbf{Y_G}$, $\mathbf{Z_G}$, $\boldsymbol{t_i)_j}$ 68** of measuring and imaging device **36** in global coordinate space **30,** whereat is recorded the three-dimensional measurements and images of the intra-oral objects and features, as described in Step 6". *See* '707 patent 21:55-64. Sub-step (b) requires the assignment of an intra-oral local space coordinates to each intra-oral local coordinate space pixel position, for **each** of the plurality of globally recorded three-dimensional measurements and images of the intra-oral objects and features. "In **FIG. 1,** for example, there is assigning intra-oral local space orthogonal coordinates, $X_{L(j)}$, $Y_{L(j)}$, and $Z_{L(j)}$, and, time, t_j, to each pixel position, for example, p^{th} pixel position **86,** located in intra-oral local coordinate space

82, for each of the previously globally recorded three-dimensional measurements and images of the intra-oral objects and features appearing in one or more fields of view, $(FOV)_k$, for example, k^{th} field of view (FOV)k **78,** for measuring and imaging device **36** located at j^{th} global position P*MID* $(X_G, Y_G, Z_G, t_i)_j$ **68.** Accordingly, each assigned p^{th} pixel position, $PP_{L(j)}$, is written in terms of intra-oral local space coordinates and time, thus, $PP_{L(j)}$ $(X_{L(j)}, Y_{L(j)}, Z_{L(j)}, t_i)_p$ **88,** with reference to the global coordinates via the measuring and imaging device position index, (j). This step further includes storing each assigned local coordinate space pixel position by central programming and processing unit **42."** *See* '707 patent 22:18-35**.** Sub-step (c) requires "transforming the intra-oral local space coordinates of each intra-oral local coordinate space pixel position, in **each** of the plurality of globally recorded three-dimensional measurements and images of the intra-oral objects and features, to the corresponding or proportionately equivalent global space coordinates, for forming a plurality of sets of global coordinate space pixel positions in global coordinate space which are registered relative to the same intra-oral fixed global registration point. " *See* '707 patent 22:35-45. Referring to **FIG. 1,** for example, this step involves applying any standard mathematical or algorithmic coordinate space registration technique known in the art, for example, involving matrix transformations, for transforming each local coordinate space pixel position, such as p^{th} pixel position, $PP_{L(j)}$ $(X_{L(j)}, Y_{L(j)}, Z_{L(j)}, t_i)_p$ **88,** in each of the intra-oral local coordinate spaces, for example, intra-oral local coordinate space **82,** to a corresponding or proportionally equivalent global coordinate space pixel position in global coordinate space **30** of oral cavity **26** of the patient. This is performed for **each** of the plurality of globally recorded three-dimensional measurements and images of the intra-oral objects and features throughout oral cavity **26** of the dental patient." *See* '707 patent 22:46-59. For all the

above reasons and more, I disagree with the opinion Dr. Egbert expressed in paragraphs 51 and 52 of his declaration.

7. "mobile registration device (for measuring and recording global positions and orientations of said measuring and imaging device)"

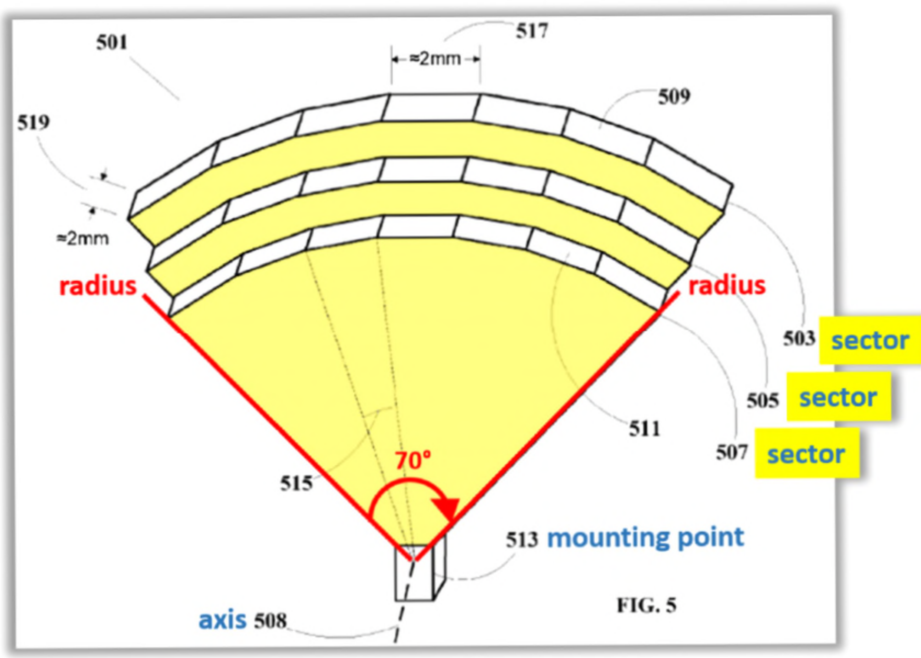
47. I disagree with the opinion of Dr. Egbert expressed in paragraph 57 of his declaration that "one of ordinary skill in the art would not have understood that [the descriptions at 18:24-19:15 of the '707 Patent] impart sufficient structure for the 'mobile registration device.'" Dr. Egbert argues that the "mechanisms," "circuitry," and "communications modes" disclosed in the specification "merely refer to generic components." Dr. Egbert is wrong in several respects. First, certain of the components of the mobile registration device are not at all generic. For example, claims 30 and 65 provide that the "mobile registration device is designed, configured, and operates according to a category of mechanisms used for measuring distances and recording positions of objects and features selected from the group consisting of group consisting of . . . electro-optical mechanisms, electromagnetic mechanisms, radar mechanisms, magnetic mechanisms, magneto-mechanical mechanisms, magnetic resonance mechanisms, acoustic mechanisms, ultrasound mechanisms, sonar mechanisms, photo-acoustic mechanisms, telemetry mechanisms, hybrid mechanisms, and combination mechanisms thereof." I do not believe that a person of ordinary skill in art would consider devices, such as magnetic resonance mechanisms to be generic. Additionally, it is my opinion that a person of ordinary skill in the art would understand that these mechanisms convey a structure of the mobile registration device.

C. DISPUTED TERMS OF THE '768 PATENT

1. "sector"

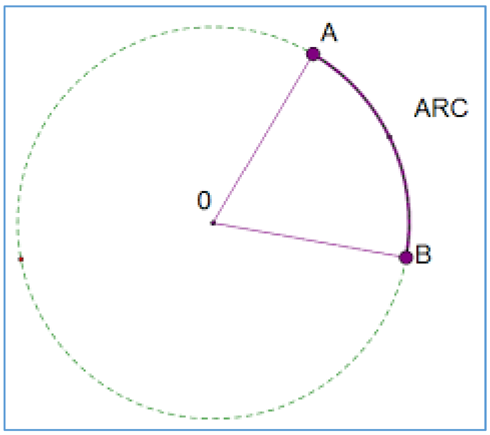
48. I disagree with the opinion Dr. Egbert expressed in paragraph 64 of his declaration that "the '768 patent describes 'sector' in the 'geometric sense,' along with the

patent's description of the term 'prism.'" In fact, the example that Dr. Egbert points to establishes that the word sector is **not being used in the geometric sense** when the specification provides that "the faces are on a multiplicity of sectors, shown as a sector 503, a sector 505, and a sector 507, each of which is a sector of a respective prism on a common axis 508, and each of which has a different nominal radius (not shown)." *See* '768 Patent at 14:36-49. Dr. Egbert also appends a marked-up version of Figure 5, which I will also use to explain the mistakes in his analysis:



First, Dr. Egbert identifies the sectors of the patent as being two-dimensional planar polygons, whereas the section of the specification that he relies on provides that "the faces [such as face 509] are on a multiplicity of sectors." *See* '768 Patent at 14:36-49. These planar prism faces are orthogonally situated with respect to the two-dimensional planar polygons identified by Dr. Egbert as being "sectors." This would in my opinion convey to a person of ordinary skill in geometry that the term sector as it is used in the patent conveys a three-dimensional prismatic

volume, not a two-dimensional polygonal region as Dr. Egbert proposes. Second, the section of the specification that Dr. Egbert relies on refers to a "sector of a respective prism." This would demonstrate to a person of ordinary skill in the art that sector is not being used in its geometrical sense, and certainly does not describe the two-dimensional polygonal region that Dr. Egbert refers to as a "sector." A sector in the geometric sense is a two-dimensional shape that is enclosed by two radii **and an arc**, as shown in the image below:



49. It is noteworthy that this definition, which is incompatible with the specification and the claims, is consistent with the two dictionary definitions that Dr. Egbert cites in paragraph 67 of his declaration. ("the second edition of the Collins English Dictionary, published in 2006, defines sector as 'either **portion of a circle bounded** by two radii and **the arc** cut off by them.' (3S_DENSYS_0005056-5058.) Similarly, the fourth edition of Webster's New World College Dictionary, published in 2005, defines sector as '**part of a circle** bounded by any two radii and **the arc** included between them.' (3S_DENSYS_0005075-5077.)"). But 3Shape's preferred definition is inconsistent with the specification's use of the word sector in two ways, (1.) it defines a sector as a two-dimensional surface as opposed to the three-dimensional volume disclosed in the specification and; (2.) the geometric definition of a sector is a two dimensional

surface **enclosed by an arc**, which is inconsistent with the figures, specification, and claims of the ’768 patent.

50. I thus disagree with the opinion of Dr. Egbert expressed in paragraph 66 of his declaration that the extrinsic evidence cited is consistent with the way that the word sector is used in the specification. The prior art examples cited by Dr. Egbert both demonstrate the use of the word “sector” as a two-dimensional shape that is enclosed by two radii and an arc, whereas “sector” as it is used in the specification describes a three-dimensional prismatic volume that is bounded in part by a multiplicity of faces at an angular orientation with respect to one another. *See e.g.* ’768 Patent, claim 1.

2. “a plurality of faces” and “each face of said plurality of faces at an angular orientation with respect to each adjacent face”

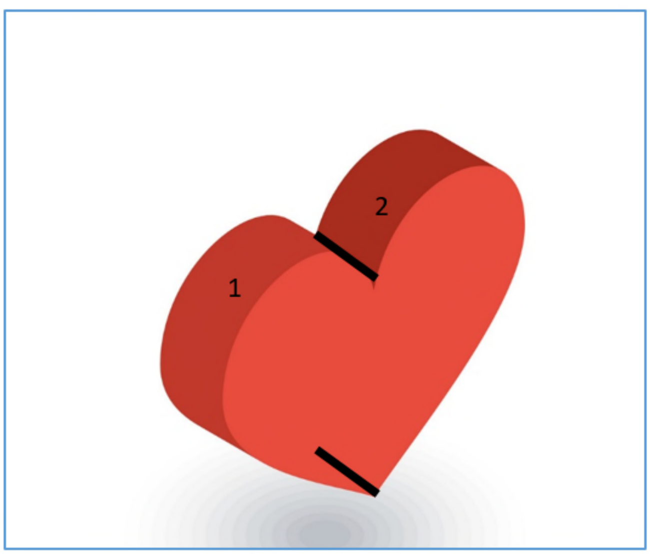
51. I disagree with the opinion Dr. Egbert expressed in paragraph 64 of his declaration that “3Shape’s proposed construction of ‘a plurality of faces’ as ‘more than one substantially plane surface’ is consistent with how that term is used in the ’768 Patent and how that term would be understood by a person of ordinary skill in the art.” I believe that a person of ordinary skill in the art would read claim 2, which provides in relevant part that “each face of said plurality of faces includes a pyramidal depression” as being incompatible with Defendants’ proposed construction, which requires that each face be “substantially plane.” *See e.g.* ’768 Patent, claim 2.

52. I also disagree with the opinion of Dr. Egbert expressed in paragraph 71 of his declaration that the construction of “’each face of said plurality of faces at an angular orientation with respect to each adjacent face’ as ‘each substantially plane surface at an angular orientation relative to an adjacent substantially plane surface’ is consistent with how that term is used in the ’768 Patent and how that term would be understood by a person of ordinary skill in the art.” My

basis for disagreeing with Dr. Egbert is the same as that provided above. *See e.g.* ’768 Patent, claim 2.

53. I also disagree with the opinion of Dr. Egbert expressed in paragraph 72 of his declaration that “[a] person of ordinary skill in the art would have understood that ‘faces’ cannot be interpreted as ‘curved’ in the context of the ’768 patent.” For example, Claim 16 of the ’768 patent provides that the “length defining the first end of said at least one sector includes an arc.” *See* ’768 Patent, claim 16. Claim 1 of the ’768 patent provides for a “plurality of faces extending along the length of the at least one sector.” *See* ’768 Patent, claim 1. Combining the limitations of claim 16 which depends from claim 1 with claim 1, demonstrates that one of ordinary skill in the art would have understood that a “face” as it used in the claims could be curved.

54. I also disagree with the opinion of Dr. Egbert expressed in paragraph 72 of his declaration on multiple counts. First “in [his] opinion, if curved faces were included, the description of the reference surface device depicted in Fig 5 would be rendered meaningless because the faces would no longer be ‘at an angular orientation’ as claim 1 requires.” This can be illustrated by looking at the diagram below:



The two-curved face of the shape above, labeled 1 and 2, are at angular orientation with respect to one another, this is because the edges shared by the two faces, shown as dark black lines, are discontinuous boundary conditions.

3. "identifiable positional characteristic"

55. I disagree with the opinion Dr. Egbert expressed in paragraphs 76-78 of his declaration that identifiable positional characteristic is not precisely explained in the specification. I will explain this term below and that its common usage by the inventors of the patent show that contrary to Dr. Egbert's claim, the term "identifiable positional characteristic" is a common and relevant term of well-known meaning to persons of ordinary skill in the art.

56. In his declaration, Dr. Egbert states that "[a] person of ordinary skill in the art would understand that there are numerous ways to identify landmarks used to stitch together 3D images and the description in the specification does not meaningfully limit such possibilities." *See* Egbert Decl. at ⁋ 78. He further states that "[i]n [his] opinion, the description of a visibly-identifiable characteristic does not provide any meaningful insight into the definition of an 'identifiable positional characteristic' to a person of ordinary skill in the art." *See* Egbert Decl. at ⁋ 80. However, the supplemental reference surface devices of the '768 patent are provided for use in three-dimensional modeling of intra-oral scenes using identifiable positional characteristics from structured illumination or other techniques. As such, the meaning of an "identifiable positional characteristic" as it is used in the '768 patent would be understood by a person of ordinary skill in the art in that context.

57. At the time of the invention, a common method of making a three-dimensional digital computer model of the surfaces of a scene was to project light reference patterns onto the "scene" (i.e. the totality of objects and domain being imaged), take an image of the scene

showing the projected patterns ("structured illumination"), and then analyze the imaged patterns in comparison with an image of the same patterns projected onto a plane surface.

58. By precisely measuring the respective displacements of the projected patterns in the image of the scene against the positions of the matching patterns in the reference image, it is possible to employ triangulation to determine the positions of the scene surfaces along the axis normal to the image plane, and thus obtain relative three-dimensional positions of the scene surfaces for use in constructing a three-dimensional model of the scene surfaces. Both regular and random patterns are used in structured illumination.

59. It should also be noted that the two-dimensional image of a scene on which structured illumination patterns have been projected, and from which three-dimensional position data can be derived, is in some sense equivalent to the three-dimensional model, which results therefrom through triangulation against the corresponding image of the patterns projected onto a plane surface, because the three-dimensional model contains substantially the same three-dimensional information as the two-dimensional image correlated with the structured illumination. A similar correspondence exists for other two-dimensional imaging techniques that result in three-dimensional models (such as two-dimensional stereo pairs). In this regard, two-dimensional images containing three-dimensional information, such as two-dimensional images of the structured illumination, and the corresponding three-dimensional models are, to some extent, interchangeable.

60. The various inventive reference surface devices of the '768 patent, considerably enhance the ability of constructing detailed three-dimensional models from the two-dimensional images, when used in conjunction with such aforementioned imaging systems. By surface mounting these disclosed reference surface devices in the oral cavity,

imaging the intra-oral scene and reference surface device, and combined use of the customized two-dimensional image and three-dimensional geometric processing techniques disclosed in the ’768 patent, there are now newer methods for accurately determining the *position* and *three-dimensional digital geometry* of an intra-oral feature. The steps involved include: (a) selecting an appropriate reference surface device; (b) attaching the reference surface device mounting so its *pointed* to the intra-oral feature; (c) simultaneously imaging the intra-oral scene and the mounted reference surface device face; (d) capturing a two-dimensional image of the intra-oral scene and the exposed reference surface device faces; (e) *identifying the position and orientation indicia* on the reference surface device faces *in* the two-dimensional image; and (f) computing a three-dimensional *position* of the reference surface device mounting point as the *position* of the intra-oral feature. *See* ’768 Patent at 6:46-57.

61. Furthermore, also disclosed is a method for producing a three-dimensional digital computer model of an intra-oral scene including: (a) selecting an appropriate reference surface device; (b) *positioning* the reference surface device relative to the intra-oral scene; (c) attaching the mounting so it *point*s to a feature having a *substantially fixed* location relative to the intra-oral scene; (d) imaging the intra-oral scene and the reference surface device, including at least one identifiable *positional characteristic* on the reference surface device; (e) capturing, from a first position, a *first* two-dimensional image of the intra-oral scene *including* the reference surface device and *at least one identifiable positional characteristic*; (f) obtaining a first three-dimensional model from the first two-dimensional image; (g) capturing, from a second position, a second two-dimensional image of the intra-oral scene *including* the reference surface device; (h) obtaining a second three-

dimensional model from the second two-dimensional image; and (i) stitching the first three-dimensional model to the second three-dimensional model according to at least one *identifiable positional characteristic*. *See Id.* at 6:58-7:12.

62. Having stated that making a three-dimensional digital computer model of the surfaces of a scene using projected light reference patterns onto the scene, taking an image of the scene showing the projected patterns, and then analyzing the imaged patterns in comparison with an image of the same patterns projected onto a plane surface, was a *common* method and *well known* to a person of ordinary skill in the art, there were several limitations in the then state of the art. The novel reference surface device designs and the methods disclosed in the ’768 patent overcome several of these limitations.

63. One severe limitation in the two-dimensional imaging and three-dimensional modeling process state of the art at the time of the patent was the inability to capture and three-dimensional model small objects and other special intra-oral features as they often lacked sufficient surface area for satisfactory three-dimensional reconstruction from projection of structured illumination patterns. *See e.g Id.* at 3:58-60. Even if three-dimensional reconstruction is achieved, there may be insufficient three-dimensional area in the “tile” (three-dimensional models of very small areas within the mouth, such as a single tooth, or an abutment portion) to enable stitching to another three-dimensional tile. *See e.g Id.* at 3:58-4:14. In addition, if a feature has a polished or reflective surface, structured illumination patterns typically are not visible when projected onto such features. *Id.*

64. The ’768 patent discloses several supplemental reference surface devices to increase the richness of the intra-oral scene in a calibrated fashion that facilitates determining precise three-dimensional positions of intra-oral features and the stitching

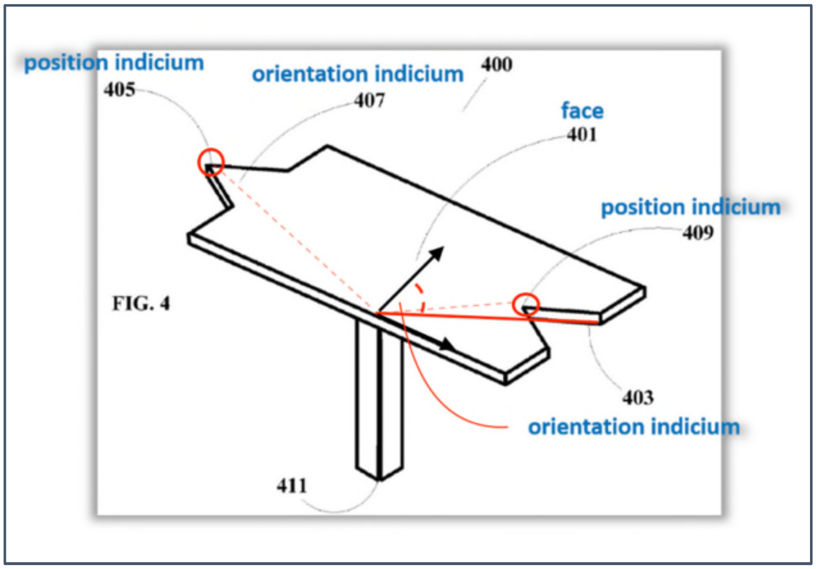
together of separate tiles by providing increased imaged area. These reference surface devices also facilitate determining the angulation and position of intra-oral features, such as abutments, teeth, false teeth and other prosthetic elements. The shape and size of the disclosed reference surface devices would provide a person of ordinary skill in the art about the limitation that the reference surface device provide "one fully intraoral reference surface operative to provide an identifiable positional characteristic". *See* Id. at claim 1.

65. For all the above reasons and more, I disagree with the opinion Dr. Egbert expressed in paragraphs 75-78 of his declaration

4. "orientation indicium" and "position indicium"

66. I disagree with the opinion Dr. Egbert expressed in paragraph 85 of his declaration that a person of ordinary skill in the art would not be able to determine with any level of reasonable certainty whether a given feature is an "orientation indicium" or a "position indicium." I will explain these features precisely below and its incorporation and novel usage in the surface device design inventions, citing from the patent specifications, and thereby show that contrary to Dr. Egbert's claim, a person of ordinary skill in the art would easily be able to determine with absolute confidence when a given feature is an "orientation indicium" or when it is a "position indicium."

67. Dr. Egbert also appends a marked up version of Figure 4, which I will also use to explain his mistaken analysis:



68. Dr. Egbert discusses a marked up version of Figure 4, which I have further annotated and included here. Position indicium **405**, **409** are **points** on the apex of the triangular features (either protruding away or cut in on the reference surface device.) and mark a fixed **position** in the 3D space. These *position indicium* are **fixed** relative to the mounting point, on the reference surface devices. The *orientation indicium* are defined by either of the two edges of the triangular features on the reference surface device. Vectors in 3D space, have an angular orientation relative to a reference surface device's local coordinate space up vector or to any global coordinate system. Boundary point features are never confused by boundary edge vectors and so the two indicium position and orientation are distinct. Having both indicia as part of the same reference surface device is innovative. Moreover, having multiple indicium on the same reference surface device adds to the flexibility in usage in correlating positions and orientations in two-dimensional images with three-dimensional positions and orientations. For these reasons and more, I disagree with Dr. Egbert's opinion in paragraph 86-87 of his declaration. A person of ordinary skill in the art would quite easily and precisely be able to delineate on a 3D reference surface device and a 2D image of the "orientation indicium" and the "position indicium."

I declare under penalty of perjury that the foregoing is true and correct.

Dated: July 23, 2020

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Chandrajit Bajaj, Ph.D.